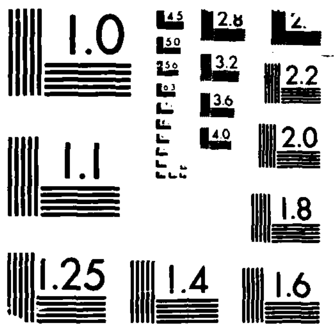
AD-A193 014 DIVIDED ATTENTION REVISITED: SELECTION BASED ON LOCATION OR PITCH(U) NEW YORK UNIV N Y L KAUFMAN ET AL. 28 FEB 88 AFOSR-TR-88-0343 1/1

UNCLASSIFIED F49620-85-K-0004 F/G 5/8 NL



MICROCOPY RESOLUTION TEST CHART
IREAU ... TANDARDS 1963 A

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

DTIC FILE COPY

Form Approved OMB No. 0704-0188

DTIC ELECTE APR 0 4 1988 D

AD-A193 814

1a. REPORT SECURITY CLASSIFICATION: unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release distribution unlimited
	5. MONITORING ORGANIZATION REPORT NUMBER(S): AFOSR-TR- 88-0343
6a. NAME OF PERFORMING ORGANIZATION: New York University	6b. OFFICE SYMBOL (If applicable)
7a. NAME OF MONITORING ORGANIZATION: Air Force Office of Scientific Research	
6c. ADDRESS (City, State, and ZIP Code): Departments of Psychology and Physics, 4 Washington Place - New York, NY 10003	7b. ADDRESS (City, State, and ZIP Code): Building 410, Bolling AFB, DC 20332-6448
8a. NAME OF FUNDING/SPONSORING ORGANIZATION: AFSOR	8b. OFFICE SYMBOL (If applicable): NL
9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: F49620-85-k-0004	
8c. ADDRESS (City, State, and ZIP Code): Building 410, Bolling AFB, DC 20332	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO	WORK UNIT ACCESSION NO.
61102F	2313	A4	

11. TITLE (Include Security Classification)
DIVIDED ATTENTION REVISITED: SELECTION BASED ON LOCATION OR PITCH

12. PERSONAL AUTHOR(S)
Lloyd Kaufman, Samuel J. Williamson and S. Curtis

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Publication	FROM 1 Jan 88 TO 28Feb88	Feb. 28, 1988	5

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The affect of attention on the level of cortical activity in human subjects was investigated by use of a novel paradigm involving the rapid and simultaneous presentation of two sequences of tones having different sets of frequencies. Measurements of the magnetic field of both the N100 and P200 components originating in auditory cortex showed enhancement for the attended sequence in comparison with the ignored sequence. This was observed whether the sequences were presented to different ears or the same ear. Thus pitch alone is a sufficient clue for attention. These results are also in general agreement with filter theories that postulate the attention of ignored stimuli prior to conscious perception.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION: unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL: Dr. Alfred R. Fregly	22b. TELEPHONE (Include Area Code): 202-767-5024 — 22c. OFFICE SYMBOL: NL

DD Form 1473, JUN 86 — Previous editions are obsolete. — SECURITY CLASSIFICATION OF THIS PAGE

07 MAR 1988

To be published in: *Biomagnetism 1987, Proceedings of the 6th International conference on Biomagnetism*, K. Atsumi, T. Katila, M. Kotani, S.J. Williamson, and S. Ueno, Editors, Tokyo Denki University Press.

DIVIDED ATTENTION REVISITED: SELECTION BASED ON LOCATION OR PITCH

AFOSR-TR- 88-0343

S. Curtis, L. Kaufman, and S.J. Williamson

Neuromagnetism Laboratory, Departments of Psychology and Physics
New York University, 4 Washington Place, New York, NY 10003, U.S.A.

INTRODUCTION

It is well known that the auditory and visual N100 components of the event related potential (ERP) measured on the scalp are modulated by attention. Moreover, many investigators have proposed that N100 is produced by multiple sources whose potential patterns overlap at the scalp electrodes (Naatanen and Picton, 1987). Neuromagnetic investigations of the event related field (ERF) have revealed that at least some portion of the N100 component, which we shall refer to as N100m, originates in the auditory cortex (Bak et al., 1981; Hari et al., 1980, 1982), and that the source or sources of N100m are modulated by attention (Curtis, 1987; Kaufman and Williamson, 1987). Thus, primary sensory activity contributes substantially to the so-called "endogenous" N100.

One of the issues related to the effects of selective attention on the ERP has to do with the classic finding in dichotic listening experiments that attention to a message can be facilitated if the message is perceived as originating in one place in auditory space, while the competing message originates at some other place. In our earlier studies of the ERF we confirmed this finding, since in a dichotic listening task the two messages were delivered separately to the two ears, and attending to one of them results in a substantially enhanced N100m in comparison to the response for the message being ignored. We now test the hypothesis that separation in quality (pitch) rather than perceived space is sufficient to produce a similar effect on N100m. This would test for the applicability of the neuromagnetic findings to those obtained in behavioral studies (see Kahneman, 1973, for a review).

METHODS

A novel dichotic listening task was employed in which 100 ms tone bursts were delivered at a rate of 3 s^{-1} to one ear and 3.5 s^{-1} to the other ear. Since neither these fundamental frequencies nor their first four higher harmonics coincide, it was possible to simultaneously average the band-limited responses and then obtain the separate response at 3 Hz together with its first four harmonics and at 3.5 Hz together with its first four harmonics. The 3 s^{-1} sequence of tone bursts had frequencies of either 1,000 Hz or 1,050 Hz, presented in random order. Similarly, the 3.5 s^{-1} sequence was independently randomized, and the tone bursts were of higher pitch, namely 3,000 Hz and 3,050 Hz. Each randomly chosen pattern was repeated after about 40 bursts (a pseudorandom sequence). Of course, the precise lengths of the two sequences were different from each other, and also from trial to trial. It is to be noted that the repeat of each randomized segment was not accompanied by any audible cue. This arrangement made it possible for the subject to attend to one of the trains of tone bursts while ignoring the other.

With the 3 s^{-1} and 3.5 s^{-1} trains presented to separate ears by plastic earphones to produce the requisite spatial localization of the two trains of tone bursts, a 5-sensor SQUID probe (Williamson et al., 1984) was placed at various positions over the subject's head to record the magnetic response. The subject was instructed to attend to one train and to determine the number of tone bursts that occurred before the pseudorandom pattern repeated itself. The accuracy of this determination provided a measure of the subject's attention. During a session the lengths of the sequences were progressively increased, to insure that the subject was fully engaged in his task. The entire procedure was repeated with the subject paying attention to the tone bursts occuring at the other repetition rate. Hence it was possible to compare responses to tones when they were attended to and when they were ignored, but when they had the same repetition rate and the same spectral

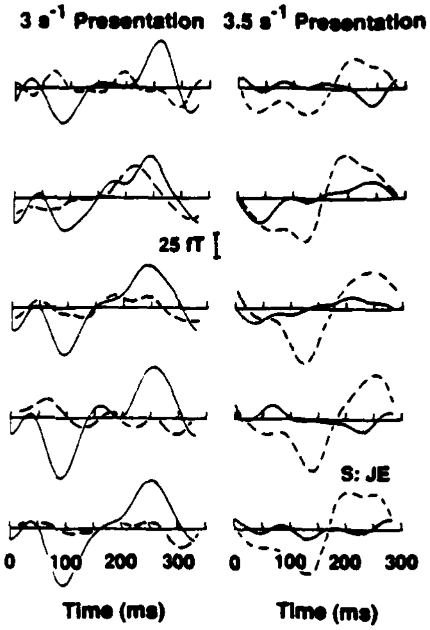


Fig. 1. Auditory evoked fields obtained over the anterior extremum of the left hemisphere averaged at 3 Hz (left column) and at 3.5 Hz (right column). The solid curves show responses when the former is attended, and the dashed curves when the latter is attended. The five waveforms of a given type in each column are the responses simultaneously recorded by the individual sensors of the probe.

composition. The probe was then moved across the head to another position, and similar measurements of the field pattern were made. This was continued until at least six different probe positions (30 measurement positions) on one side of the head were covered. Similar measurements were conducted over the other hemisphere as well. This was repeated for each of three subjects.

RESULTS

Figure 1 illustrates the waveforms obtained for the attend and ignore conditions when the fundamental and first three harmonics are added together. The attended stimuli evoke strong components having latencies of about 100 ms and 200 ms. The latency of the latter component of the 3.5 s^{-1} responses is slightly longer at 250 ms than for the 3 s^{-1} responses, which may be due to the increased task difficulty associated with the faster repetition rate. The responses obtained with the faster rate were also weaker. These components are similar to the N100 and P200 components obtained by Hillyard et al. (1973) for averaged transient responses, when tone bursts are presented separately in random order. The primary difference is that the 200-ms component in our data was modulated by attention, whereas P200 reported by Hillyard et al. was not. However, Hillyard et al. reported that the amplitude of the N100 was modulated by 30-40% between the attend and ignore conditions, which is comparable to the effect shown by our 100-ms component.

Comparison with Transient Responses

Studies of the transient evoked field were conducted to determine whether the neural sources of the classic N100m and P200m components coincide with the sources of the 100-ms and 200-ms components observed at our higher presentation rates of 3 s^{-1} and 3.5 s^{-1}. Figure 2 gives one example of the good correspondence of positions of the extrema for outward (+) and inward (-) directed fields. The corresponding difference for the positions of equivalent current dipole sources, lying midway between the respective extrema (Williamson and Kaufman, 1982), is less than 1 cm, comparable to the uncertainty in the measurements. Hence, we may conclude that our 100-ms and 200-ms components are the same as N100m and P200m obtained using stimuli separated by long interstimulus intervals.

Analysis of Variance

An analysis of variance (ANOVA) was performed using the field amplitudes measured at 20 different positions near the field extrema for each of 3 subjects, where attended responses were significantly greater than background noise. No consistent hemispheric differences were found, nor were there significant differences between the amplitudes of N100m and P200m. There were significant differences among the amplitudes of

A-1

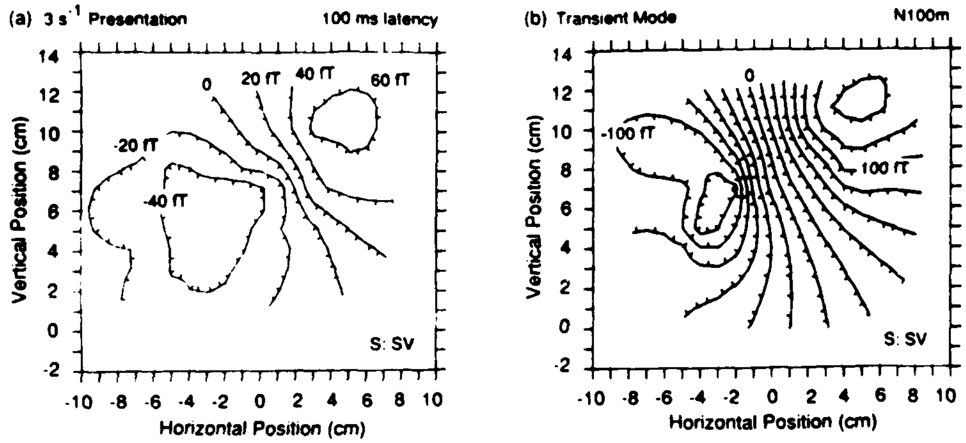


Fig. 2. Isofield contours over the left hemisphere of a subject for (a) the 100-ms component evoked by an attended 3 s^{-1} presentation rate of 1 kHz tones and (b) the N100m component evoked by a 200 ms tone burst with an interstimulus interval exceeding 500 ms. Contours are at 20 fT intervals. The horizontal coordinate indicates distance along the line passing through the ear canal, at (0,0), to the outer canthus of the eye; and the vertical coordinate is distance above this line measured along a perpendicular to the line.

the peaks measured at different positions, but this is to be expected as the different positions were at different distances from the field extrema. The most important finding was the effect of instruction to attend to a stimulus. This produced amplitudes of N100m and P200m that were greater than the corresponding amplitudes found when the stimuli were ignored (Fig. 3a). This difference was significant with $p = 0.028$. A similar analysis was performed separately on the first three harmonics of the responses after their waveforms were analyzed by means of an FFT (for subject CB). There was no significant effect of instructions on the 2nd and 3rd harmonics. The effect of attention was fully accounted for by changes in the amplitude of the fundamental component of the response. Moreover, in each hemisphere of the subjects there were substantial and systematic variations in the computed tangential current dipole moments of the sources that depended solely upon instruction. We conclude from these studies that activity originating in auditory cortex is modulated by attention. There is no sign at all of neural activity in extra-auditory areas that may contribute to auditory-evoked electrical N100 and P200 measured near the vertex by Hillyard et al. (1973).

In a control experiment one of the two stimuli was reduced in intensity by 20 dB. This had no effect on the amplitude of the response, whether it was a response obtained while the subject was paying attention to the stimulus or a response while the stimulus was being ignored.

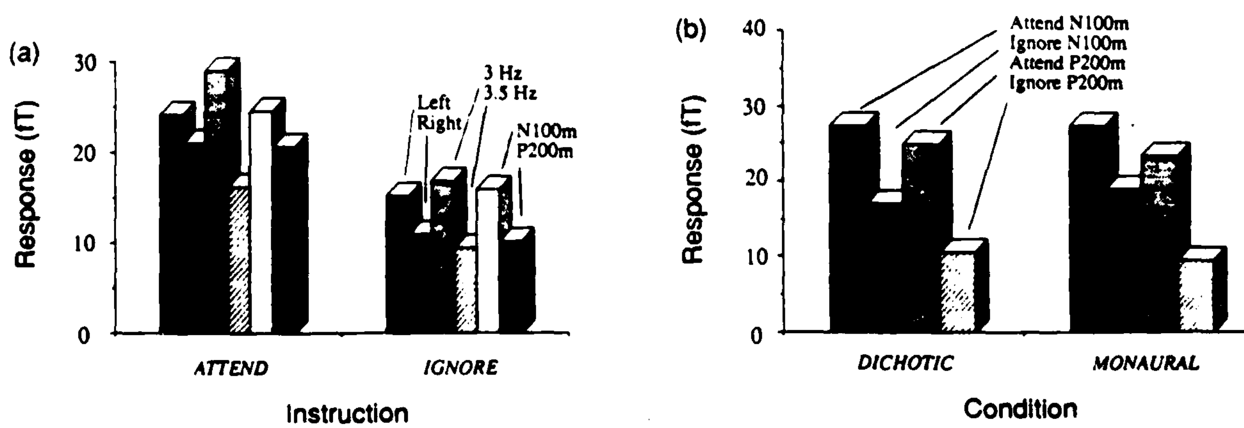


Figure 3. (a) Effect of the instruction to attend a stimulus, for left and right hemisphere responses to 3 s^{-1} and 3.5 s^{-1} stimuli, for both N100m and P200m components. (b) Response strengths of N100m and P200m for dichotic and monaural presentation, when attended and ignored.

Dichotic vs. Monaural Presentation

To determine whether pitch differences alone mediated the effect, the two stimuli were applied to two different loudspeakers placed adjacent to each other and about 1 m from one ear, thus enabling both signals to be heard by both ears without artifact. For one subject, the N100m and P200m components were enhanced as a result of attending to one of these trains of tone bursts by the same amount as when they were presented dichotically. This was followed by a systematic experiment in which the two different trains were presented to one ear alone through one earpiece of the headset used in the main experiment. Thus, the only cue available to the subject was the difference in pitch of the two different trains of tone bursts. The result was that the effect of instruction was statistically the same as that obtained when both pitch and location were available as cues to permit the subject to divide attention between the two stimuli (Fig. 3b).

DISCUSSION

The main conclusion to be drawn from these results is that activity originating in the auditory cortex is modulated by attention. There is no sign of activity in extra-auditory areas contributing to the attentional effect. While we cannot rule out the possibility that such sources may contribute to the effect of attention on the electrical N100 and P200, the magnitude of our effect suggests that such additional sources would add very little to the modality-specific effect of attention. These results are in general agreement with filter theories of attention that postulate the attention of ignored stimuli prior to conscious perception (Treisman, 1969).

ACKNOWLEDGEMENT

Research was supported in part by Air Force Office of Scientific Research Grant F49620-85-K-0004.

REFEFENCES

Bak, C., Kofoed, B., Lebech, J., and Saermark, K. (1981). Auditory evoked magnetic fields from the human brain. Source localization in a single-dipole approximation. Phys. Lett., 82A, 57-60.

Curtis, S. (1987). Auditory attention and the neuromagnetic field. Ph.D. thesis, Department of Psychology, New York University.

Hari, R., Aittoniemi, K., Järvinen, M.-L., Katila, T., and Varpula, T. (1980). Exp. Brain Res., 40, 237-240.

Hari, R., Kaila, K., Tuomisto, T., and Varpula, T. (1982). Interstimulus interval dependence of the auditory vertex response and its magnetic counterpart: Implications for their neural generation. Electroenceph. clin. Neurophysiol. 54, 561-569.

Hillyard, S.A., Hink, R.F., Schwent, V.L., and Picton, T.W. (1973). Electrical signs of selective attention in the human brain. Science 182, 177-180.

Kahneman, D. (1973). Attention and Effort, Prentice-Hall, New Jersey.

Kaufman, L., and Williamson, S.J. (1987). Recent developments in neuromagnetism. In: Barber, C., and Blum, T., Eds. Evoked Potentials III: The Third Evoked Potentials Symposium, in press.

Naatanen, R., and Picton, T. (1987). The N1 wave of the electric and magnetic response to sound: A review and analysis of the component structure, in press.

Treisman, A. (1969). Strategies and models of selective attention. Psych. Rev., 76, 282-299.

Williamson, S.J., and Kaufman, L. (1981). Evoked cortical magnetic fields. In: Erné, S.N., Hahlbohm, H.D., and Lübbig, H., Eds. Biomagnetism, Walter de Gruyter, Berlin, pp. 353-402.

Williamson, S.J., Pelizzone, M., Okada, Y., Kaufman, L., Crum, D.B., and Marsden, J.R. (1984). Magnetoencephalography with an array of SQUID sensors. In: Collan, H., Berglund, P., and Krusius, M., Eds., Proceedings of the Tenth International Cryogenic Engineering Conference, Butterworth, Guildford, pp. 339-348.

END
DATE
FILMED
8-88
DTIC